

## Specifications for Multi-tip STM/nanomanipulator System

The Naval Research Laboratory (NRL) requires a multi-tip, ultrahigh vacuum scanning probe microscope (SPM) system. This system must meet or exceed the following specifications.

Summary: An ultrahigh vacuum (UHV) facility containing 4 opposed, independent, simultaneously-operable probes with the potential for scanning tunneling microscope (STM) operation in the same UHV chamber, with associated control electronics, imaging software, computers and monitors. The sample mounting and transfer system must be compatible with the Omicron sample transfer system and should be roughly consistent with the layout in the attached drawing. *STM upgradeability of at least one probe to perform AFM is highly desirable.* The system must be upgradeable with an in-situ high-resolution scanning electron microscopy (SEM) and scanning Auger microprobe (SAM).

### System Layout and UHV Chamber

The system must feature sample/probe exchange and introduction of all four probes via wobble sticks (at least 2 total) - therefore there must be access to the STM probes from at least three sides.

- A leak-tested ultrahigh vacuum (UHV) system containing ion pumping with ultimate system pressure of  $1 \times 10^{-10}$  Torr and appropriate ion gauging.
- Vibration isolation is achieved by auto-leveling air legs. The connection of the STM module to the sample transfer system and thence to other chambers (NRL will provide at least 1 in addition to the airlock) will consist of a gate valve and an air pressure compensated bellows assembly, to ensure optimal performance of the damping legs. A comprehensive vibrational analysis of the final site will be carried out by the vendor on request.
- UHV Transfer chamber and all mechanical transfer/sample handling devices, to include rotary long-travel manipulators (5) and associated adaptors to enable sample transfer to manipulators at  $90^\circ$  or wobble sticks in indicated positions, 1 extra adaptor to fit existing long travel manipulator, pumping system and pressure measurement, fast entry airlock chamber with gate valve isolation, double bellow assembly for decoupling of multi-tip STM module to other UHV modules (2), bakeout, and system controller.
- The vacuum chamber has a base flange for the STM stage and ports for fast entry chamber, wobble sticks, ion gauge, pumping, SED, electron column, aperture control, viewports, RGA, hemispherical analyzer and auxiliary.
- A storage carousel (with positions for a combination of 10 probes and samples) is fitted to the STM chamber or to an auxiliary chamber, or if unavoidable, to the fast entry chamber.
- The whole assembly rests on a heavy-duty table with pneumatic, auto-leveling vibration isolation.
- The sample reception stage accepts OMICRON standard sample plates or their equivalent and is fixed to the probe station base plate.
- The system must be capable of accommodating a high-resolution scanning electron microscope (SEM) with 5 nm resolution at a working distance of 10 mm. The

proposed SEM must be capable of imaging the sample while the sample is in position for multitip STM analysis, so that it can be used for probe tip navigation.

- The system must be capable of accommodating a hemispherical analyzer for SAM application to the 4-tip STM module, without altering or compromising the SEM performance. The angle between the electron column and the analyzer will be approximately 60°; the working distance of the SEM column will not be affected by installation of the SAM.

Sample Stage: The sample stage must have the following characteristics:

- X/Y piezo driven translation over a 10 mm x 10 mm coarse positioning range.
- High precision X/Y-table (25 mm x 25 mm) for whole stage with atmospheric micrometer screw control.
- Temperature variable between 50 K and 500 K including LHe transfer tube and Dewar with a temperature controller for the flow cryostat
- Position Readout of all X/Y axes of the 4 probes: 8 sets of sensors and PC board modules for position readout for the four X/Y-piezo translation stages of the probes; readout resolution 30nm.
- Four probes each mounted to a 1" single tube scanner. Each probe can be positioned independently using piezo drives in 10 mm x 10 mm x 5 mm (X/Y/Z) area. The 1" scanner provide a fine positioning/ scan range of 5  $\mu\text{m}$  x 5  $\mu\text{m}$  x 2  $\mu\text{m}$ . The STM tips on top of the scanners are magnetically clamped and can be exchanged by means of a pincer grip wobblestick.

#### SPM control system

Control electronics and software for data acquisition and processing with STM mode only. Upgradeability for AFM operation is highly desirable.

Package consists of:

- Modular control unit for each STM tip, preferably upgradeable for AFM operation, including the following slot cards: Real-time Measurement Controller (single board computer with MC68040 processor or better) with High Performance Serial Bus (IEEE 1394, or better), computer control by macro command language. Coarse positioning board for piezo inertia drives. VectorScan Generator with full area offset and scan width control. Six-channel piezo driver for tube scanner. Digitally controlled analog feedback loop for STM or AFM operation. 20 bit D/A converters for gap voltage, tunneling current set point, and Z-offset. TwinAD board for simultaneous four-channel 18 bit data acquisition.
- Tips which are not capable of STM-imaging (probes) will be capable of positioning with motion control of roughly 50 nm steps in XYZ, as well as a piezo scanner for fine manual z control with 1 nm resolution and a Z-regulation module with constant current feedback with TTL bland input, set point control and tip bias, an STM I/V converter, and preamp.
- Windows NT computer: Preconfigured personal computer with high performance serial bus IEEE 1394 for data acquisition; Processor specifications to current standard. Minimum hardware configuration: 256 MB RAM, 40 GB hard disk, CD-RW drive, 250 Mb Zip disk drive, Ethernet, keyboard, mouse. Windows NT workstation and Drivers installed. Includes a 21" monitor.

- Software package for SPM imaging, spectroscopy and nanolithography with SPM hardware and simultaneous data analysis and image processing. The software runs on a Personal Computer under Windows NT or Windows 2000. Data acquisition requires a Windows NT Computer. Included are an IDL runtime environment and a single user runtime license of the application software and IDL. Software release updates, at least once a year, will be offered for the application software and the IDL environment (free of charge for two years after delivery).
- The control system must provide imaging capability for the relevant STM probe tips as described in the options below, as well as full Z-control with feedback for constant current I/V- and I/Z- spectroscopy, Z-offset control and a nano-lithography interface.

Please provide quotes on the following subsystem components, and on the aggregate systems, as described.

Version 1: 1 STM-capable imaging tip and 3 probes (with and without position readout) (includes preamp and cabling)

Version 2: 2 STM-capable imaging tips and 2 probes (with and without position readout) (includes preamp and cabling)

Version 3: 3 STM-capable imaging tips and 1 probe (with and without position readout) (includes preamp and cabling)

Version 4: 4 STM-capable imaging tips (includes preamp and cabling) (with and without position readout)

Please provide additional estimate for wiring and appropriate feedthrough access to install 3 electrical contacts on one STM-tip .

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- ◆ Striped boxes are gate valves
- ◆ 5 long-travel manipulators

